Final report

Evaluation of connectivity and Internet of Things solutions for Murchison House Station

Project code: P.PSH.1112

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Abstract

The project was divided into two phases the first of which was implementation and the second was monitoring and evaluation of the implemented technologies.

The objective of Phase 1 was to provide optimised Internet access through Wifi set-up, establish support and maintenance, and ensure set-up of solar power and information for MLA website. Origo has performed radio frequency survey, planning and implemented a private Wifi network, a Wireless Local Area Network (WLAN), including point-to-point links to Kalbarri to provide Murchison House Station (MHS) with Internet access services up to the standards provided by NBN Co. Origo has also performed an initial evaluation of bandwidth usage including constraints. Our initial results show that the bandwidth of the NBN iiNet Service in Kalbarri is providing on average 25 Mbit/s down and 15 Mbit/s up capacity, whereas the MHS private network provides an average of 100 Mbit/s both up and down. However, when the performance of the iiNet Internet service deteriorated, it was decided to move to Telstra NBN. MHS was disconnected for approximately 4 weeks during a changeover between NBN service providers.

The Internet part of the system was in its entirety paid for by owners of MHS. The project team were grateful to the property owners for agreeing to and undertaking this research project and allow the project team access to their internet systems to learn about performance and usage.

The objective of Phase 2 was to provide remote weather monitoring, remote water management and monitoring, and remote muster monitoring. Phase 2 has been divided into 3 stages with stage 1 and 2 successfully completed. Stage 3 and the development of Mustering systems was delayed due to colder weather and the inability to trap goats on water points. This has given the project team more time to work on an optimised system for mustering through use of water traps. The concept of which has been successfully tested.

Baseline cost for benchmarking has been established through working with MHS to establish benefits to MHS and the red meat industry. Weather stations and Water management systems have been successfully implemented and valuable experiences gained with regards to utilisation of Industrial Internet of Things (IIoT) network systems in one of the most demanding environments in WA. Origo has been working with MHS to further develop user interfaces for Dashboards. The project has also integrated satellite imagery data from Cibolabs demonstrating the power of using Open source software for server and client-side computing.

The project demonstrated Origo.farms Digi Mesh network usage over 100,000 hectares of very challenging terrain. This coverage has not been previously demonstrated.

The project also demonstrated that considerable savings can be made from remote monitoring and control of water assets as well as benefits related to understanding of trends in weather patterns. The total annual savings in water management, including cost of system amortised over 5 years, was calculated to be $39,500 per annum. This is more than 50% of the total cost of water management at MHS per annum which is at an average of $75,000-80,000 per annum.

The project has not been able to ascertain benefits from the mustering system related to water traps for goats. This aspect will require further investigation beyond the current project.

Development and implementation of the Agriculture IIoT system was funded by Origo and MLA.However, MHS provided substantial in-kind support the project through providing masts and solar power as well as cutting tracks where required. Where changes to the system beyond the original project scope were required due to learning in the project, this was funded by Origo.

As of this report, MHS operates as both a tourism enterprise (at around 60-70%) and livestock operation (at 30-40%). MHS has also stated that they have applied for carbon farming projects which will change their farming system considerably. It is anticipated that data collected on farm from sensors and internet connectivity installed as part of this project will support MHS carbon farming initiative going forward.

Executive summary

Background

The purpose of this research, includes:

- Provide the best possible Internet Access Solution in the area. Test feasibility with regards to bringing NBN services from nearby Kalbarri to Murchison House Station.
- Secondly, to test if low-power Industrial Internet-of-Things Technology (IIoT) could be used to for weather monitoring, make water management and mustering more efficient and sustainable. Remote water management covering both monitoring and control in a particularly challenging landscape over approximately 123,000 Ha.
- The target demography is extensive livestock producers, relevance across all MLA sectors.
- Demonstrate the feasibility and savings by use of IIoT in extensive livestock production

Objectives

- Provide optimised Internet Access services by using Wifi Technology to extend NBN services from Kalbarri to Murchison House Station.

- Demonstrate and test using IIoT across Murchison House Station to provide weather data, remote monitoring and control of water systems and mustering system.

- Field day to demonstrate benefits and efficiency provided by use on technology in extensive livestock operations.

- Document efficiencies and benefits with regards to use of technology in extensive livestock production.

Methodology

- Installing Wifi and IIoT technology including a meshing network to cover the complete Murchison House Station livestock operation.

- Test technology for use cases in Murchison House Station livestock operation, in all parts of the season.

- Interviews of owner/operators as well as collection of information with regards to before and after situation.

- Organising field day in cooperation with local agriculture college in WA Midwest as well as invitation through to all local grower groups.

Results/key findings

The IIoT network and devices worked successfully across all selected locations at Murchison House Station. The Meshing network provided a much better coverage than anticipated and the use of expensive Wifi technology is not required for anything else than high-speed Internet Services. It demonstrated that this network technology can be used at a large scale without large infrastructure investments.

Considerable savings has been achieved with regards to water management, based on the numbers provided by Murchison House Station, the annual cost was reduced from $77,600 to $39,500, which is would be around a 50% reduction in costs. Based on these results Murchison House Station continues to invest in technology to increase efficiency and sustainability, including to contribute to carbon farming.

Wifi Technology provided more capacity in terms of network speeds available in Kalbarri, the project successfully demonstrated that Wifi can be used to create links that extends NBN services from nearby locations where NBN terrestrial services are available.

The field day was successful with participation from producers in the area and most importantly the WA Agriculture college in Morawa.

Benefits to industry

The project provides findings that support that usage of technology in extensive livestock operations will provide benefits with regards to operational cost-efficiencies, animal welfare and ability to adjust farming system both tactically (in-season) and planning based on data from weather stations as well as water management based on remote monitoring and control.

Future research and recommendations

The meshing IIoT network provide technology that require less infrastructure investments. It is recommended to research and develop systems based on this platform that demonstrate that IIoT can be used at scale for instance for use in animal tag systems, vehicle and asset management and tracking as well as staff text communication.

The results were also used in MLA Project P.PSH.1179 Making Real Farms Smart – Mixed Sheep Ag Tech.

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1 Background

This final report summarises findings from the MHS project through the project phases described below.

Phase 1

Solar Power and Mast Infrastructure Requirements and Establishment

Requirement and establishment of infrastructure to support stable and reliable operation of MHS private high-speed Wireless Local Area Network or “WLAN”.

Perform a radio frequency survey to ensure no interference in the 5 GHz spectrum for any of the 3 links in the point-to-point network or on the local 2.4 GHz spectrum at MHS. Visual inspection to check obstructions from desktop planning and modelling.

Installation of optimal Internet Access Service for MHS

Link the NBN Co service in Kalbarri to MHS WLAN and optimise NBN Co service within the remits of the retail service provider offering.

Service Monitoring and Maintenance for MHS

Establishment of continuous Monitoring and Maintenance Services.

Phase 2

Remote Weather Monitoring

- Rainfall
- Solar Radiation – Sun hours and Evaporation
- Temperature and Humidity
- Anemometer - Wind and Wind Direction
- Barometric pressure
- Evapotranspiration – Drying Rate

Remote Water Monitoring and

- Flow Sensor on Supply
- Aquifer where relevant for Open Water Source
- Pump and Valve Monitoring and Control where relevant
- Either Water Tank System or Open Water Source

Remote monitoring in Mustering systems

- Monitoring of livestock movements and entry/exit points (count in/out)
- Situation Awareness waterpoints with camera and timelapse
- Automated or remotely controlled gates
- Passage Sensor for entry/exit points - Monitoring of livestock movements and count in/out.
- Timelapse image capture for Situation Awareness at mustering points

Reporting requirements will include:

1. Typically, what the data is used for (i.e. social media, business, etc)
2. Social interviews on how the social aspect of farm business and life has changed (or not) with connectivity (including kids schooling/education, safety improvements etc)
3. How the business has changed (anecdotal and real)
4. Any financial benefits that can be articulated.

For Internet Access Service the report will also cover:

1. Bandwidth
2. Data peak use
3. Speed (max, min, average, ideal) (Latency comparison)
4. Reliability of link including downtime
5. Additional value adoption (New thoughts/ideas on how to value add the system

2 Project objectives

2.1 Phase 1: Internet Connectivity and Farm Wifi Network

Phase 1 objective was to:

- Extend Internet Access service available in Kalbarri through 4 Wifi point-to-point links to the station homestead.
- Provide Wifi Access Points throughout the homestead, including selected office, yards, homes, workshop and sheds.
- Agree on quarterly Monitoring and Evaluation framework.

This network was further extended in phase 2 as a backbone for the IIoT network.

2.2 Phase 2: Station Ag IIoT Network

The objective was to provide a network to enable monitoring and control of assets critical for managing pasture, livestock and staff including creating efficiencies and cost-savings in the MHS operation.

Additionally, the objective was to test this architecture and establish a methodology fit for the Australian livestock industry, based on Origo.farm experience in the grains and mixed grains and livestock market segment. This would involve testing the feasibility of using the IIoT network without a Wifi back-bone therefore further utilising the meshing capabilities of the network technology to determine both coverage and reliability.

2.3 Phase 2: Remote Weather Monitoring

The objective was to measure parameters critical for pasture, livestock and staff in the MHS operation, specifically:

- Rainfall – rainfall events and trends and aggregated totals for a week, month and year
- Solar Radiation – daily status and trends and aggregated totals for week, month and year
- Temperature and Humidity – Current value and trends and aggregated totals for week, month and year.
- Anemometer - Wind and Wind Direction – Current value and trends and aggregated totals for week, month and year.
- Barometric pressure – Current value and trends and aggregated totals for week, month and year.

Discuss which calculated values will be of value to MHS operations, such as:

- Evaporation
- Sun hours
- Dewpoint

2.4 Phase 2: Remote Water Monitoring and Remote Water Control

The objective was to measure parameters critical for managing water resources in the MHS operation.

- Either Water Tank System or Open Water Source. Monitoring water volume and status for every minute and provide trend for day, week, month and year. Status is currently updated every minute.
- Flow Sensor on supply and exit. Monitoring water flow as a status for every minute and provide a trend for day, week, month and year.
- Aquifer where relevant for Open Water Source. Monitoring of water level in the open aquifer as the level in mm from the bottom of well. The status will be critical, normal, full.

Update frequency is configurable and can be from every 15 min to a selected frequency, e.g. every hour as required.

Further objectives were to control and measure parameters critical for managing water assets in the MHS operation:

- Diesel pump control. Implementation using Kensho Control panels integrated with the Origo.farm system for remote control and fail-safes.
- Electrical pump control 240VAC system. Implementation using Origo.farm systems for remote control and fail-safes.
- Valve Monitoring and Control. Implementation using Origo.farm systems for remote control and fail-safes.

2.5 Phase 2: Remote monitoring in Mustering systems

The objective was to create operational awareness to enable a more efficient muster as well as ensuring animal welfare in the MHS operation.

- System for remote closing of the gate. The closing of the gate using Origo.farm remote control system controlling a solenoid closing the gate.
- Time-lapse camera system for image capture for situation awareness at mustering points and water traps. The speed of time-lapse configurable down to 1 image per minute at daytime.

Remote control system for gates and time-lapse camera system is independent to enable flexible use of camera system in mustering situation.

2.6 Monitoring, evaluation and reporting Phase: Internet usage and performance

The objective was to ensure that Internet access services are made available at a level where it could be used for modern station management as well as for social and educational purpose .

Interviews with regards to usage patterns and monitoring of Internet usage and performance in the period from 25 May 2018 to 5 October 2018.

2.7 Monitoring, evaluation and reporting Phase: Social interview on how the social aspect of farm business and life has changed

The objective was to understand how technology can influence socio-economic factors. This includes improved Internet services, impact farming practices and business as well as the social impacts on a pastoral operation.

2.8 Monitoring, evaluation and reporting Phase: Additional value adoption: New thoughts/ideas on how to value add the system

The objective was to provide information with regard to ideas that have been developed through Phase 1 and 2 of the project with regard to the value-add of the system to MHS as well as increased value to the meat and livestock industry.

3 Testing and Development Methodology

3.1 Phase 1 Infrastructure and Communications planning

3.1.1 Solar and Power Infrastructure

Origo has been providing engineering requirements with regards to solar power and structural requirements to MHS. MHS is environmentally conscious and would like to re-cycle materials to a large extent.

3.1.2 Radio Frequency Planning and Site Survey

Radio frequency planning using desktop tools as basis for a Site Survey to locations potentially suitable to verify positions, and potential obstructions and measurement of radio frequency emittance to understand potential interference issues using standard RF Analyser equipment.

Planning of links performed according to best practice to ensure margins with regards to terrain, adverse effects of weather and potential interference as well as operating within the Australian Communications and Media Authority (ACMA) regulations.

3.2 Phase 2 Ag IIoT Network Radio Frequency Planning and Site Survey

Radio frequency planning using desktop tools was performed initially and used as the basis for a Site Survey. The site survey evaluated selected locations. This included verifying positions and considering potential obstructions and measuring radio frequency emittance to understand potential interference issues using:

- Standard hand-held Radio Frequency Analyser equipment for all bands.
- Wifi frequency testing equipment/app for 2.4 and 5GHz bands.
  - Android App.
  - Ubiquiti RF testing software supplied in hardware.
- Custom testing equipment for 900MHz Mesh network.

Planning of links was performed according to best practice in order to ensure adequate margins with regard to terrain, adverse effects of weather and potential interference as well as operating within the Australian Communications and Media Authority (ACMA) regulations.

3.3 Weather Stations

Stations sensors were calibrated and tested after receival from the factory by use of standardised testing equipment provided by the manufacturer and as established by international bodies, such as the WMO (Word Meteorological Organisation). End-to-end connectivity was tested when installed as well as checking that sensor data was within limits throughout a 4-week test period.

3.4 Water monitoring

Stations sensors were calibrated and tested from the factory using standardised engineering methods, e.g. testing sensors against known volumes of water and calculating that sensors constants comply with water volume. End-to-end connectivity was tested when installed as well as checking that sensor data is within limits throughout a 4-week test period.

3.5 Water Control Systems

Station sensors were calibrated as were control safeguards upon receival from the factory by using standardised engineering methods to check e.g. voltages against documented voltage ranges for the sensors. Parameters for control systems required configuration with regard to the specific engine or motor installations. This included items such as max temperature, RPM, max run-time, shut down and start-up configuration.

Valve control was tested through end-to-end connectivity and system testing as it involves simple control of one or more valve solenoids. Sensors providing state and position of valves are through functional configuration and testing procedures at installation.

End-to-end connectivity was tested when installed and controls were normally tested through 3 controlled runs with testing of all scenarios. This included ensuring that sensors and configuration are within limits throughout a 4-week test period.

3.6 Mustering Systems

Implementation and tests were divided into

- Development and test bench
- Configuration and field test
- Configuration and operational test

Remote Gate control

Control system was a simple control of on/off position of one or more solenoids. The test procedure was very similar to Water control systems with fewer parameters as it is only an on/off for one or two solenoids.

Remote Mustering Camera

The remote mustering camera development methodology is based on a requirement for remote situation awareness at mustering points taking into consideration power, robustness, portability, network coverage, image quality and update frequency.

The camera was developed to work in the 900MHz network to maximise coverage using the same infrastructure as for other sensors systems. This is a new and unique approach as normal Internet technology enabled cameras depend on much higher power requirements and Wifi technology which increases costs considerably.

3.7 Internet usage and performance

This is measured through standard tools integrated into network equipment as well as interviews.

3.8 Social interviews on how the social aspect of farm business and life has changed

Interviews were used as the methodology to establish a baseline that can be benchmarked against in later interviews to understand change.

Interviews were performed using an interview template focussed on additional value adoption: New thoughts/ideas on how to value add the system

Interviews and information collected through project activities were actively documented throughout the project.

4 Results

4.1 MHS Wifi and Ag IIoT Network

A robust network is a foundation for farm monitoring and automation. The selected combination for network technologies was:

- Wifi IEEE 802.11.x for the network 'backbone' as point-to-point links using 5GHz, the Australian Communications and Media Authority (ACMA) so-called 'Wifi band'.
- IIoT Mesh networking using IEEE 802.15.4 in the 900MHz spectrum, the so-called ACMA 'Medical and Industrial band'.

Every station is both transmitting and receiving data and can act as a repeater for other stations in its network.

Mesh topology may be contrasted with conventional star/tree local network topologies in which the bridges/switches are directly linked to only a small subset of other bridges/switches, and the links between these infrastructure neighbours are hierarchical. While star-and-tree topologies are very well established, highly standardized and vendor-neutral, vendors of mesh network devices have not yet all agreed on common standards, and interoperability between devices from different vendors is not yet assured.

This is in comparison to some modern IIoT networks which are hierarchical with star-and-tree topologies with high capacity and high-cost Gateways (Base stations).

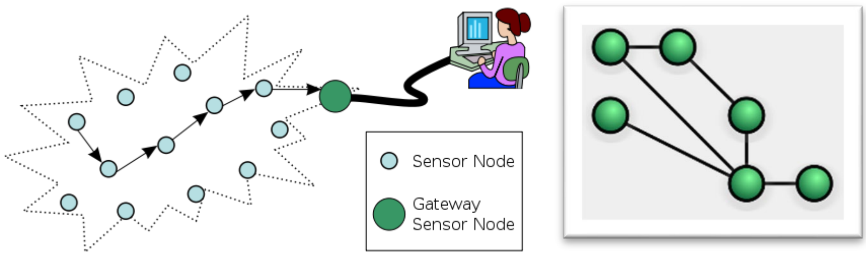

Figure 3: Wireless Sensor Network - WSN (left) and Mesh Network Topology (right)

Furthermore, cost-efficient repeater stations can be established to increase coverage in hard to reach locations as well as increase meshing quality of the IIoT network. This network architecture is described to be "self-healing" as every station can have multiple paths to the central gateway.

For this network 250mW radio modules have been utilised, the experiences through this project and other deployment has led to upgrading the output power of the devices to 1W as is possible under the ACMA regulation. This has been utilised to establish some of the largest meshing agriculture IIoT networks in Australia.

Solar Power and Mast Infrastructure as required and agreed was implemented by MHS.

- Repeater Stations as well as Base stations at Mark's Hill and Weerinougouda, see figure 4 below

MHS re-used structures such as windmill towers and refrigerator enclosures. The structures are installed according to cyclone proof specifications. These were successfully installed and inspected. The inspected installation of infrastructure showed high-quality workmanship using a high level of re-cycled materials with appropriate protection against very harsh environmental conditions.

Desktop Radiofrequency (RF) planning was performed for all stations. This planning was also revisited after field testing.

- Point-to-point Wifi links all successfully implemented without any changes, see figure 4 below.

Figure 4: Wifi Equipment including homestead Wifi

The 900MHz mesh network planning was tested in the field and the following results required changes to the implementation:

- Tutula Mill tank is in a low location and required a Repeater station to be implemented (Repeater 1). RF Planning was revisited to ensure that this Repeater would strengthen the meshing capabilities of the network as well as the Coastal network.
- Yorkgum Gate tank is in an enclosed valley with high stone hills on three sides and very limited visibility to the north-east. RF Planning was revisited and decision on a Repeater location was made. This location required a track to be cut through the bush to the new location named ‘Moner’. This repeater also strengthens the meshing capabilities of the 900MHz network working with the Bindarri East Repeater.

All locations were successfully implemented after these changes had been made.

Three Repeater stations have been implemented as planned. During installation and in meetings with MHS it became clear that MHS wants to be as independent as possible from Telco carriers. Origo is, therefore, planning the implementation of 2 further Repeater stations. This has not been implemented as of this report.

The Wifi network acts as a long-range back-bone network from south to north at MHS. The IIoT 900MHz network spurs off from each of the base stations at Mark’s Hill (B5) and Weerinougouda (B6) utilising the IIoT network meshing capabilities along the coast without the Wifi backbone to create a large mesh network.

It is important to understand that Origo has demonstrated on other properties that utilising the 1W radio modules would ensure that a Wifi network is not necessary unless a producer wants to implement high-speed Internet away from the homestead. This brings considerable cost-savings (CAPEX) with regards to infrastructure (masts and solar power) as well as in technology.

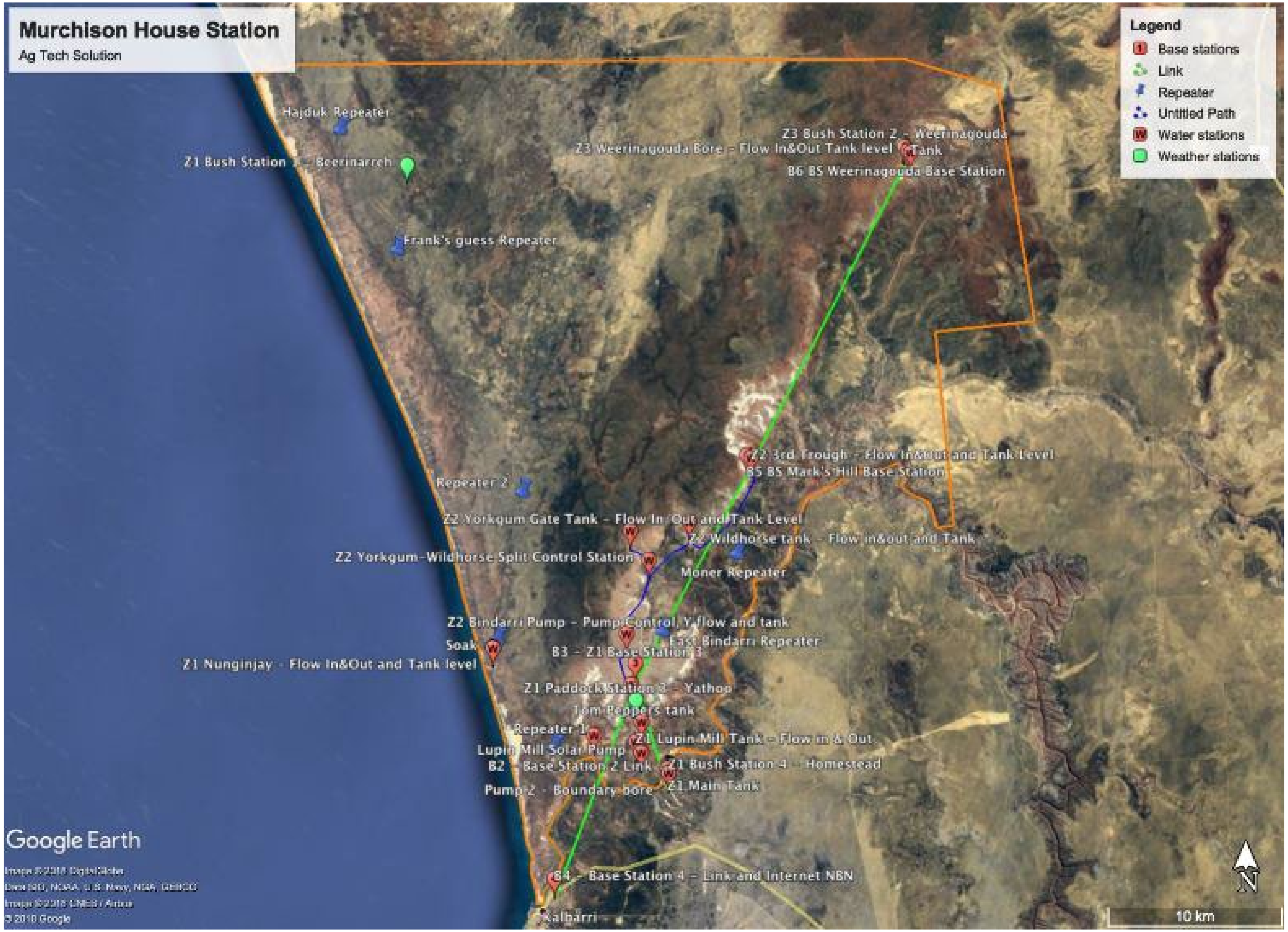

Figure 5: All stations in Wifi and Mesh 900MHz IIoT network

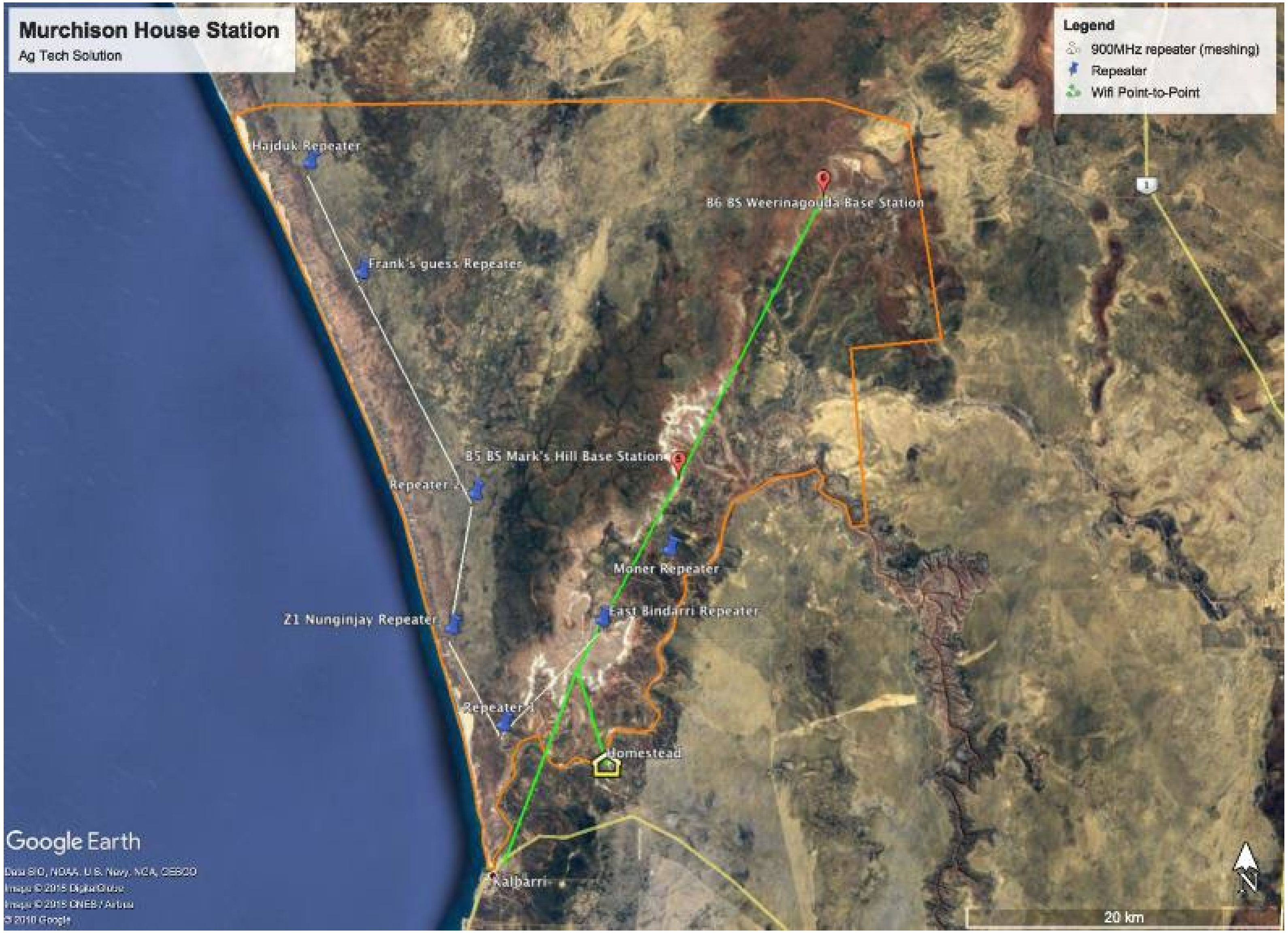

Figure 6: Base stations and repeaters in the network

4.2 Remote Weather Monitoring

Weather stations are all implemented using the 900MHz network. The reason behind this is the following:

- Cost, otherwise, the implementation of satellite-based stations would substantially increase operational expenditure.
- Coverage, because Weather station in the bush will form a part of the Meshing 900MHz network and further strengthen the meshing capability of the network and therefore its robustness.
- A Wifi station was tested at the Homestead and was not successful, the Wifi range for this type of small IIoT devices is only less than 50 metres and is not recommended. Even if this station is within this radius a decision was made to convert to 900MHz Mesh network as this is more reliable and the station will form a part of the meshing network.
- MHS wants to be independent of Telco providers as much as possible.

Stations were successfully implemented. Firmware was later updated to increase the data update frequency to 1 minute for the whole network. The update frequency will be revisited based on feedback from MHS. The choice of the high frequency updates was due to the network being utilised for Controls where rapid response is required, e.g., it is important to be able to shut off an engine quickly due to pressures and in case of failures. Controls in this case is control of diesel, electrical pumps, valves and gates requiring responsiveness and timing.

The update frequency of one minute can be called close to “real time” and is unique compared to other similar systems.

The Dashboard graphics were updated with current status diagrams during the implementation period. Screenshots can be downloaded from here: https://bit.ly/3niFlHx

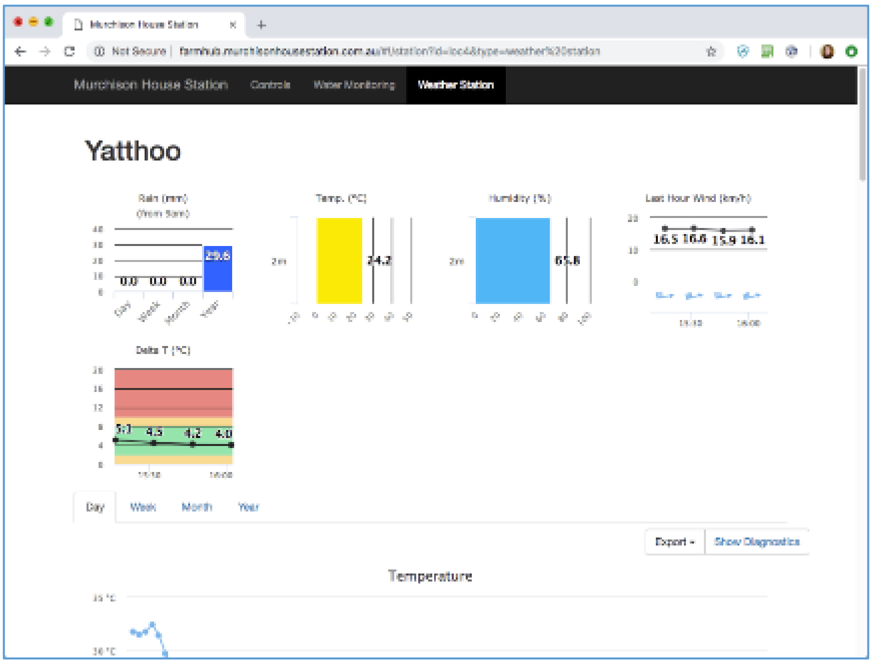

Figure 7: Example Dashboard Paddock and Bush Stations

Establishing automated weather stations with the following sensors to monitor climate conditions for livestock and vegetation:

- Rainfall in mm using tipping rain bucket with 0.2mm accuracy.
- Solar Radiation
- The temperature in degrees Celsius (±0.2C) and Relative Humidity in per cent (±2%RH)
- Anemometer – Wind speed in Kmh and Wind Direction in degrees (±2%)
- Barometric pressure mmHg (±2%)

Figure 8: Yatthoo Weather Station

4 Weather stations was established representing the various local climate zones:

- Coastal - North. Was not installed as MHS has not decided to install the remaining two repeaters yet.
- Murchison river valley at the homestead
- Murchison river valley at Paddocks
- Inland East – Weerinougouda

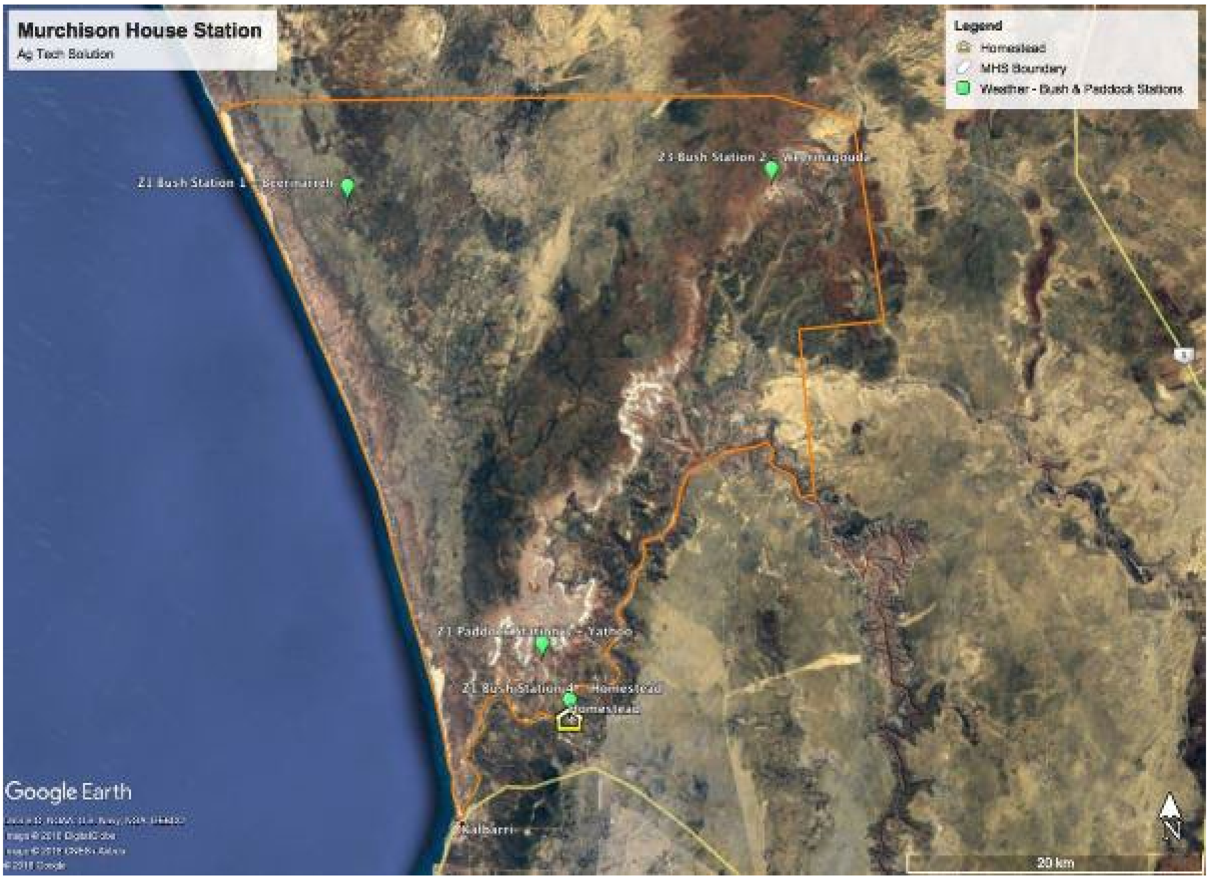

Figure 9: Weather stations – in the Bush and on Paddock
(Beerenarah delivered but not installed due to MHS priorities)

The project also researched if calculated values such as sun hours and evaporation will be of use to MHS operation, however, MHS decided that standard weather data values are sufficient for their operation.

4.3 Water monitoring

Planned water monitoring stations have been successfully installed at MHS. There are two distinct water systems used at MHS with the following characteristics:

- The isolated autonomous water system
    - Tank open or closed. Tanks are being upgraded to closed poly tanks.
    - Water sourced using either pump (24VDC solar or windmill) or soak.
    - Output to trough.
- The connected pipeline water system
    - Transfer and holding tanks with input and output
    - Endpoints for water supply to troughs and supply.
    - Water sourced at start points using electrical or diesel driven pumps (diesel engine, 240VAC pump).

Water monitoring stations were successfully installed with the following experiences and changes:

- The requirement for user-based over-ride of calibration.

- Standardised installation system for flow sensors that ease maintenance and replacement, especially for pipeline water systems as well ensuring quality installation.
- Connector systems changed for ease of installation and maintenance.
- Extension of the antenna to be above water tanks to avoid radio frequency interference and strengthen meshing network capabilities. Utilisation of 1W radio modules instead of 250mW modules.
- Filter systems required to avoid clogging up of sensors. Standard filter systems mesh was too fine to be utilised for application in areas with lime scale issues in water systems. Filter systems were successfully modified to work in these conditions.
- The mounting system for water level sensors developed due to heavy condensation on the sensor.

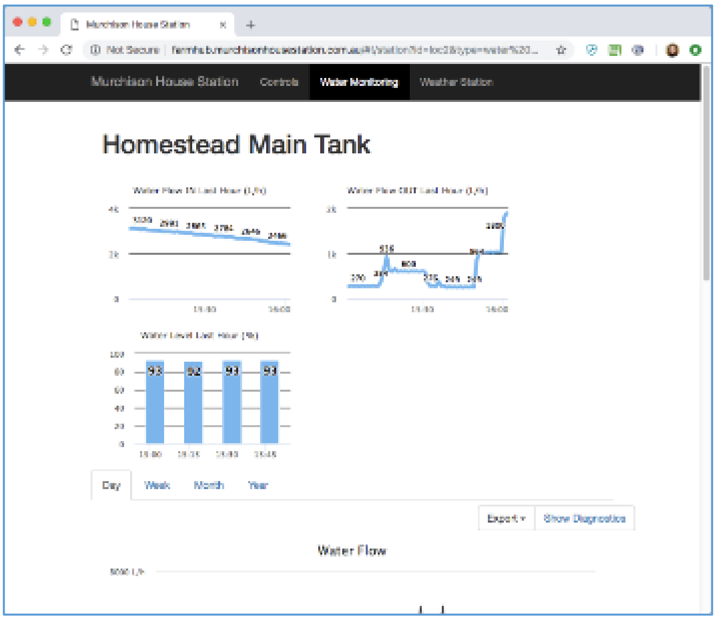

Figure 10: Example Dashboard Water station

Screenshots of Dashboards are available on this link: https://bit.ly/3niFlHx

The project established water monitoring stations with the following sensors to monitor the status of water points, pipelines and troughs:

- Tank water level using the ultrasonic sensor in litres (±10L)
- Water flow in and out of tanks as well as water sources using a hall effect sensor in litres per hour (±5%)

Seven water monitoring stations have been established as planned. Three additional stations are being planned as discussions with MHS during installations required changes at 3 points along the water pipeline system.

4.4 Whole of the Farm system

All stations and controls are integrated in the same system Dashboard, see figure 1, this makes it a ‘Whole-of-farm” system instead of having individual software packages for each part of the system.

This is a web-based Dashboard generated automatically based on meta-data and time series data from the IIoT devices in the system.

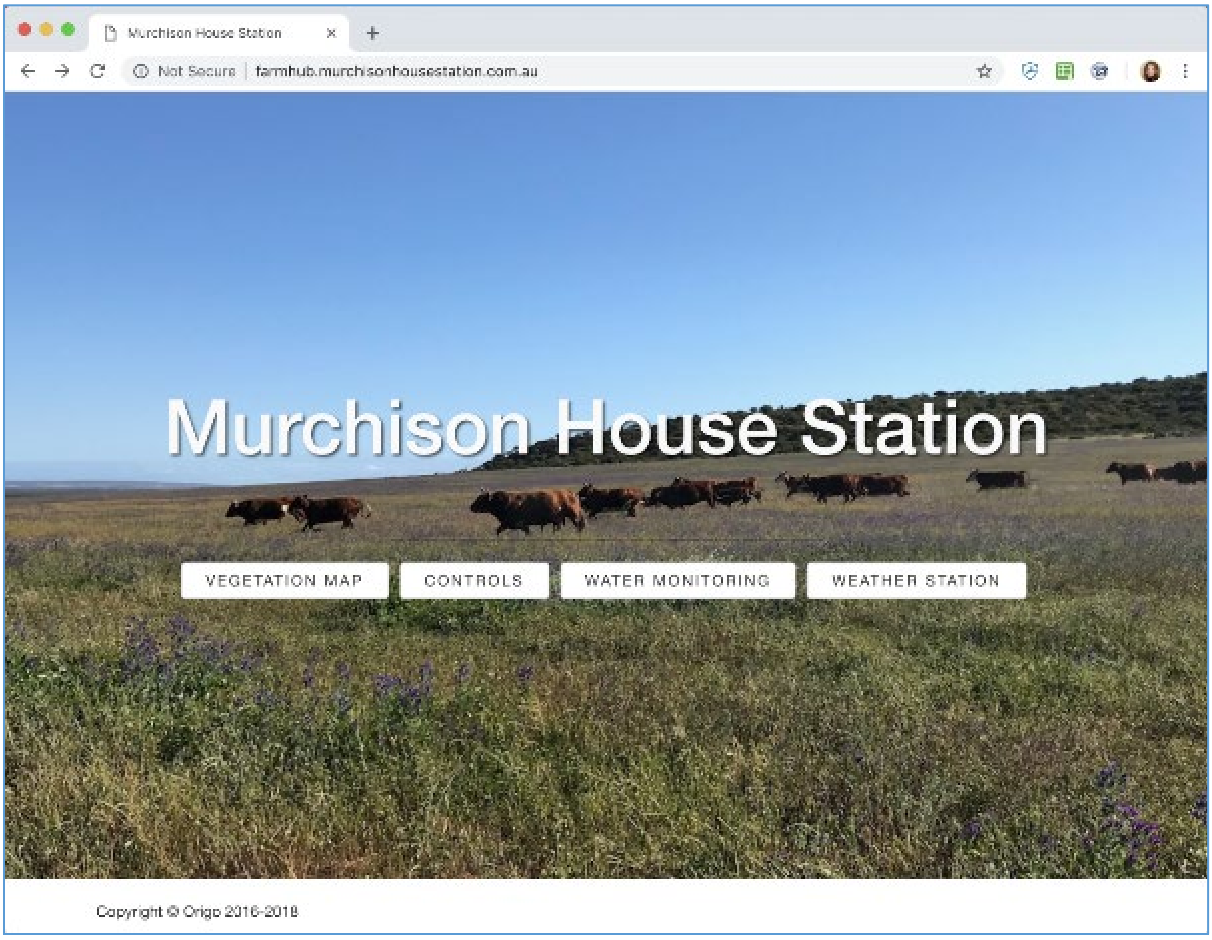

Figure 1: Web-based Dashboard

4.4.1 Integration of External data

Origo.farm has integrated data from an external source to demonstrate the strength of using Open source systems in the Livestock industry. Cibolabs is a satellite imagery service provider and in cooperation with Cibolabs we have integrated a demonstration of weekly pasture status maps. We will work with MHS to understand how this can be useful in their operation as well as look at the wider applicability in the livestock industry. Cibolabs has kindly provided their weekly data feed for a trial period.

The integration is done through an interactive map tool called 'Leaflet' and data is provided on a Microsoft Sharepoint data share. The data is uploaded automatically to the MHS Farm Server on stations to ensure very fast response time as well as storage of time series data.

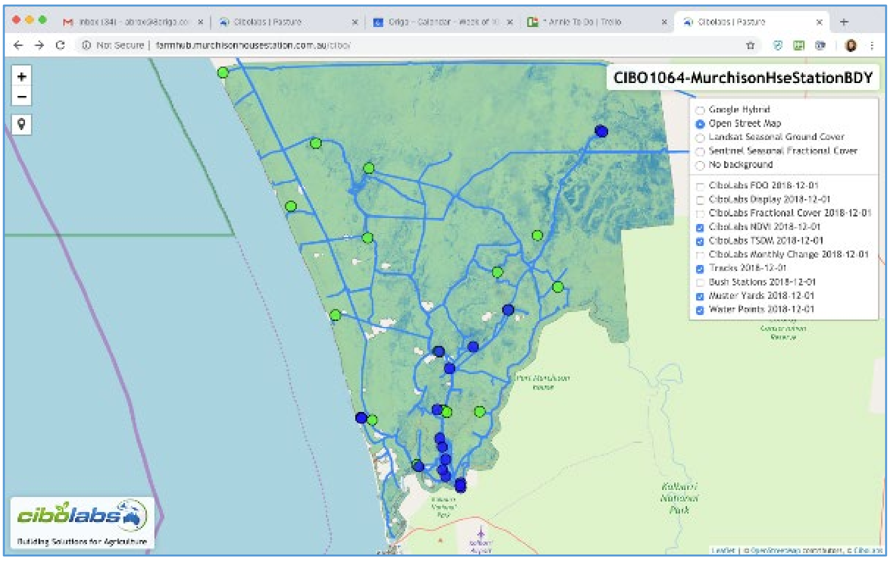

Figure 2: Cibolabs Vegetation Index Map example. Weekly updates provided in the trial period.

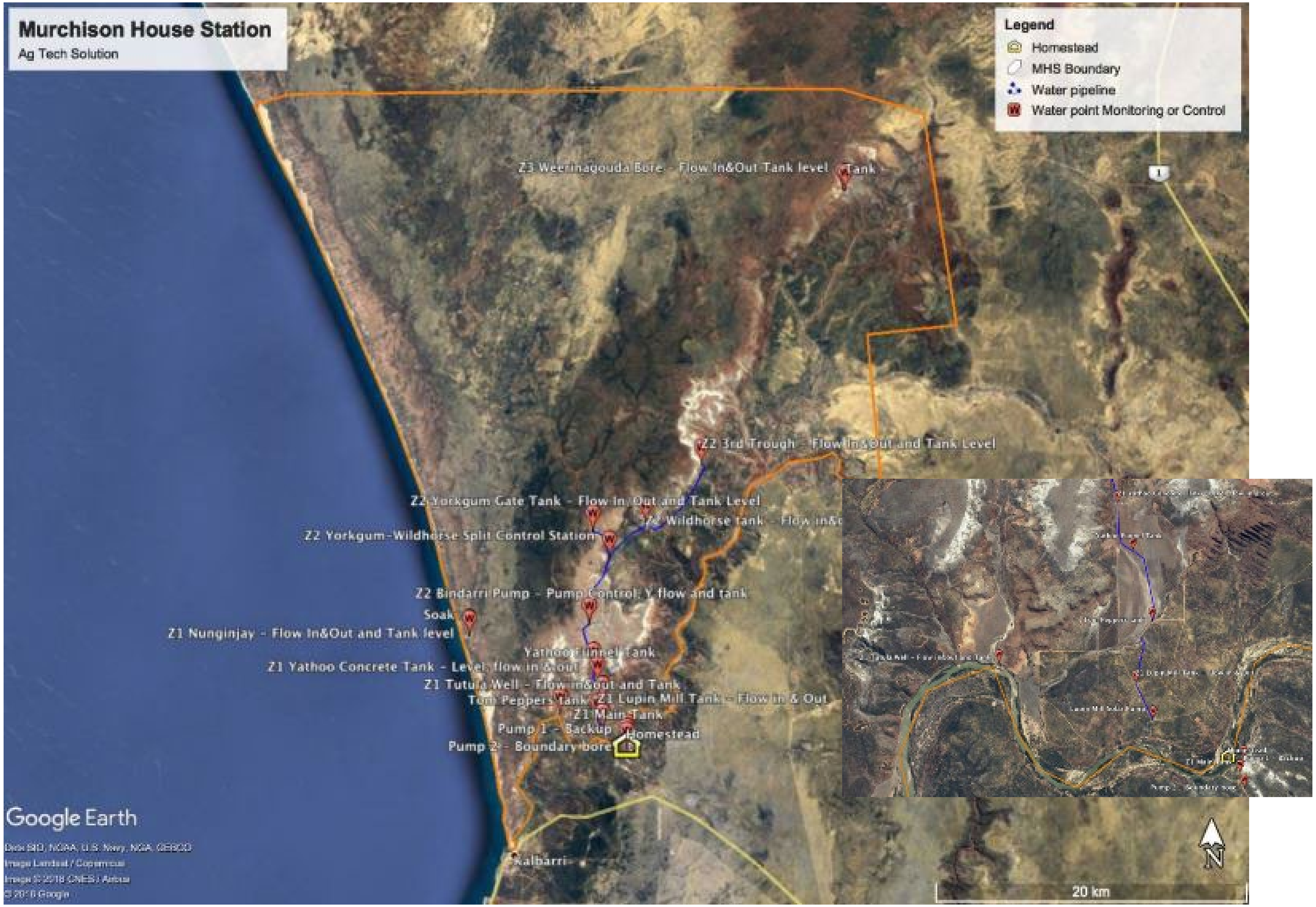

Figure 11: Water stations overview

Figure 12: Selection of water stations

4.5 Water Control Systems

The project has developed systems to control:

- Diesel pump at Bindarri well developing a generic integration using Kensho Panel systems.
- Developed Remote Valve Control systems for
    - Y-splits and Bindarri well and
    - Yorkgum gate-Wildhorse tank junction
- Workshop Auxiliary electrical pump control.

Three Water control stations were planned and established.

Water control systems are divided into 3 categories a) Diesel Pump Control, 2) Electrical Pump control 240VAC and c) Valve monitoring and control.

4.5.1 Diesel pump control

These control systems were successfully developed and tested. This included an MHS upgrade of the diesel engine. The pump house and systems have been prepared and are ready to be installed.

Development and tests are based on a Kensho panel and diesel engine simulator provided on loan by Kensho Australia.

- Fail-safes implemented as a configuration in Kensho panel.
- Remote control and fail-safes implemented as part of the Origo.farm system.
- Tests performed by use of a simulator.

The system functioned without any issues until the diesel engine had a catastrophic break-down. As the replacement diesel engine was an older second-hand engine it required considerable work to integrate controls of this engine. This integration has not been completed by the electrician at this point and it is unclear if parts can be sourced to integrate this engine completely as it is a very old model.

4.5.2 Electrical pump control 240VAC system

The electrical pump control system is installed in Workshop and acts as a manual pump control in case the main pump for the homestead water systems fail.

Development and tests based on existing Origo.farm systems configured to be used by MHS.

- Controller installed and tested at 240VAC power source.
- Remote control tested and passed.

This is a manual override function based on Dashboard status of the Main tank. The system has been functional and used throughout the project.

4.5.3 Valve Monitoring and Control

Initially, two off-the-shelf valve systems, typically used in residential irrigation systems, were tested and did not pass testing because there is a need for a low-power solution to enable cost-efficient implementations in an IIoT network fit for MHS pastoral requirements.

- A 12VDC relay-based system requiring a momentous pulse of less than 10mS passed requirements for a low-power solution.
- The residential irrigation systems type valve passed initial tests as they were tested with constant pressure.
- Implementation of valve control monitoring is based on a combination of flow sensors and 12VDC valves. These were successfully tested and installed. However, these diaphragm valves require constant pressure to be functional. The pipeline systems on MHS does not provide constant pressure, therefore the valves where not functional.

Origo decided to buy and develop systems for industrial type valves which would be suitable for the application. The development and testing at other Origo customer sites have been concluded successfully, however, MHS is planning to finalise its implementation of the replacement valve control this summer. This part has been wholly funded by Origo and results are submitted as goodwill to the project.

Figure 13: Industrial valve for remote control in livestock water systems

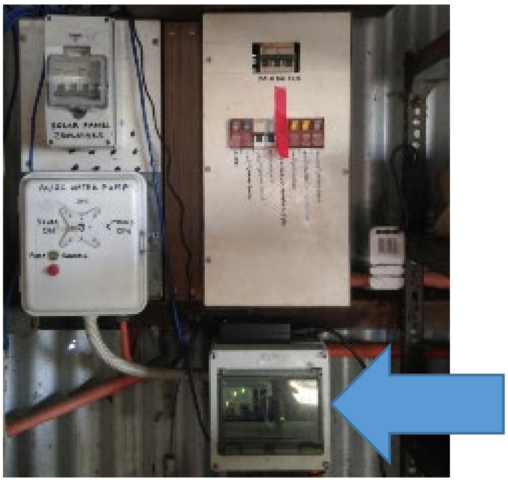

Figure 14: Control station, arrow marking control device

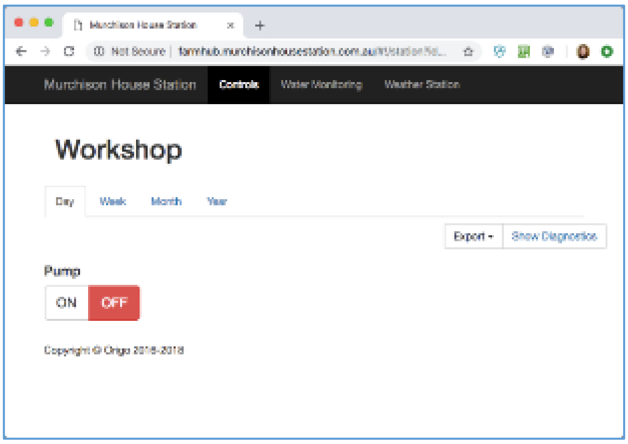

Figure 15: Example control on Dashboard

4.6 Mustering Systems

4.6.1 Remote gate control

The development is divided into 2 parts:

- Control device integration with Origo IIoT device and
- Command transfer including acknowledgement of system status (closed/open).

Development and tests have been successfully completed.

This development was coordinated with the development of valve control for Water systems as it is the same requirement for control of a solenoid system.

Figure 16: Example control on Dashboard

Initially, the solenoid will trigger shutting the gate only, as opening the gate would require a loading/opening mechanism that requires more power. MHS is working on a gate design and Origo is providing the triggering mechanism and its remote control.

MHS is currently experimenting with different gate design that will fit with their terrain and water trap systems.

4.6.2 Remote Mustering Camera

The development is divided into 3 parts:

- Image data capture based on cameras with sufficient resolution for situational awareness. The flexibility of camera with regard to focal distances is ensured in the system because lenses are interchangeable between wide angle, normal and telescopic options.
- Image data transfer capacity and frequency.
- Image data processing into time lapse video.
- Simple dashboard User Interface to ensure maximum usefulness during mustering.
- 1080 x 720 pixels Resolution
- Sending images to Server automatically
- 900MHz network transfer
- Selectable time-lapse, e.g. 1 every day to 5 minutes
- Number of photos per day only limited by the size of battery and solar panel

Link to example of time lapse video from camera can be found here: https://bit.ly/3niFlHx

Figure 17: Mustering camera system during field tests

The development has been completed and field tests have been successfully completed.

Configuration has been selected to be:

- Resolution 640x480 pixels which results in file size around 240-300KB based on requirement for situation awareness within 200 square metres.
- Image capture frequency of 5-10 minutes.

The configuration was based on actual field test imagery and discussed on location. Example imagery and time lapse shown below and can be downloaded from here: https://bit.ly/3niFlHx

Figure 18: Mustering camera system during operational testing

Operational use and experiences showed that further development was required to utilise camera for mustering. Origo has been developing the required hardware, however not having customer requests from paying customers on this feature has delayed the development of the software for the camera.

4.7 Internet usage and performance

4.7.1 Planning, development and implementation

The Phase 1 solution was successfully completed and passed testing on the 25 May 2018.

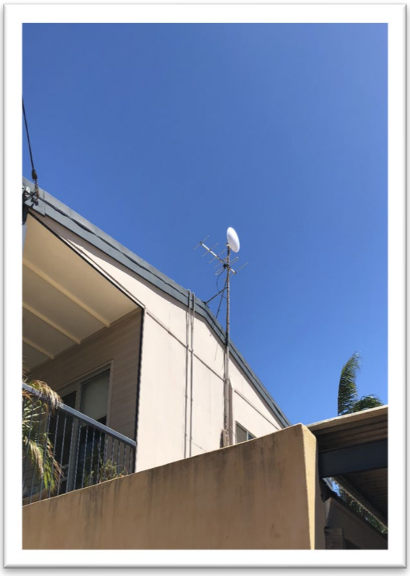

Figure 19: Main Base station at the "Jump-up" (left) and at Internet Access point in Kalbarri (right)

Figure 20: Wifi Access points sheds & workshops (left) and at homestead yard (right)

Figure 21: Overview map (top) and detail map of MHS WLAN at homestead (bottom**)**

4.7.2 Results

Link monitoring was established on the 5 June 2018 and terminated as of Q4 2019

The conclusion is that there have been three experiences with regards Internet access services throughout the project:

1. Deterioration of initial NBN service provider performance during the period, which lead to migration to a new NBN service provider.
2. Unstable power situation at MHS as well as solar power supply and Base Station.
3. Issues with regards to migration from initial NBN service provider.

Internet - Maximum speeds as measured by automated speedtest tool.

Period	Latency Average in Ms	Download Average Mb/s	Upload Average Mb/s
Q3 2018	51.87	21.72	14.19
Q4 2018	60.72	12.89	12.52
Q1 2019	61.71	12.74	12.25
Q2 2019	59.08	9.99	8.73
Q3 2019	60.38	11.06	9.19
Q4 2019	62.21	10.08	10.26
Grand Total	**59.33**	**13.08**	**11.19**

Table 1: Efficient speeds based on usage. The graph shows an increased usage trend with including a mid-winter increase in usage, RX is ‘Upload’ and TX is ‘Download’

The link is used concurrently by up to 4-5 households as well as MHS business requirements in the office, workshops and in the yard. MHS business use also includes tourism but does not provide Wifi to tourists.

The NBN speed at the IInet service provision interface in Kalbarri is now measured at 23/15 Mbit/s download/upload using the Speedtest app and can vary by 15% depending on the time of day.

No outages reported after a power supply was replaced during the test period. Latency mainly depends on the overall usage of links by concurrent users. All latencies are well below limits to be able to use links for interactive services such as IP telephony and video services such as Skype and Whatsapp.

Signal strength for the point-to-point link with the lowest average signal strength is well above limits of the disconnect value at -120dBM to ensure no deterioration in bandwidth capacity due to adverse effects from weather conditions. However, signal strengths must be monitored as it normally indicates if antennas have been blown out of position with consequences for link quality and bandwidth.

Daily usage patterns show a great variation in usage, this varies mostly with holidays. As this is an NBN unlimited service there is no data quota and the following table shows month usage in Gigabytes. This indicates that in addition to business and financial use the Internet link also provides MHS with other internet services routinely enjoyed by users of the world wide web and provides important social functions and benefits including access to social media and educational resources. This has been confirmed through informal information provided.

The average monthly usage is 460.88 Gigabyte per month, this is close to 0.5 Terabyte per month.

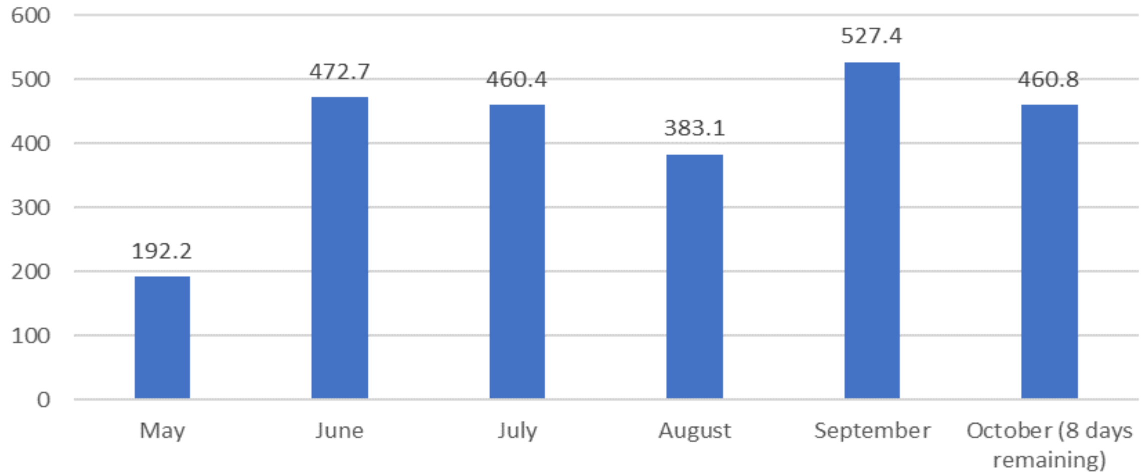

Figure 22: Monthly usage in Gigabytes

The IINet NBN service provided in Kalbarri:

- This service is advertised as 25 Mbit/s down and 10 Mbit/s up (25/10) speeds, the NBN iiNet 25/10 plan. The actual speed was 15/5 (±15%) for this plan.
- The iiNet service plan was then upgraded from the 25/10 plan to the 50/20 plan, this resulted in an actual speed of 23/15 (±15%).

Please note that FTTN NBN is not a fibre service, but a VDSL2 service on the last mile. The NBN service is also limited by the backhaul services regulated by the Connected Virtual Circuits (CVC) price/capacity structure enforced by NBN Co.

Initial user experience with 5-6 concurrent users during business hours shows that the limited speed provided by the NBN Co service in Kalbarri is the bottleneck. This is even more pronounced later in the afternoon when there is a combination of school work and entertainment use.

It is important to note that Internet services, such as the NBN Co service in Kalbarri, cannot be benchmarked against the bandwidth requirements of any one application only. The normal international measure is the bandwidth and performance requirements for a number of concurrent users in a business usage situation based on the application requirements in use. In this case, it is a combination of business, education and entertainment usage. The change in performance from the services available before the establishment of this service can be summarised in the table below.

SERVICE	SPEED DOWN/UP MBS	QUOTA GB PER MONTH	LATENCY M/S	CHARACTERISTIC
		BEFORE		
TELSTRA MOBILE 3G	5/1 (±25%)	5-40	20-500	Single user
NBN SKYMUSTER	20/5 (±25%)	80	600-800	1-2 concurrent users
		AFTER		
NBN IINET/ORIGO	23/15 (±10%)	Unlimited	25 (average)	3-5 concurrent users

Table 2: Comparison of Internet services before and after

Definition of applications in use is not simple as there is a mix of normal residential usage (Internet browsing and streaming) as well as business usage: Internet business apps such as banking, accounting, as well as mobile apps and interactive services such as WhatsApp, Document sharing, Skype, Wifi Calling.

Also, performance is also measured with regards to network stability (jitter) and latency. These factors are critical to being able to utilise e.g. interactive services like voice and video as well as the use of interactive services over the Internet. The results are positive and services like Wifi calling, Skype and Voice over IP can be utilised.

Quarterly reporting on Internet services and usage in this project has shown that MHS and the families on the station are using the Internet capacities as expected for a combined small family business as well as for social requirements. There have been no formal studies in Australia on these requirements. Experience from large international Telco operations (by author, information from 5th largest global mobile operator) has shown that small businesses without any quota limitations are satisfied with speeds in the range of 50-100Mbit/s supplied as a symmetric service with equal speed for upload and download. MHS is currently operating with approximately 50% of this as a download speed and 25% for upload speed. This is limited by the NBN supply in Kalbarri, not the MHS Origo Wifi network that is operating above 100Mbit/s symmetric service.

PDF reports of calculations are available here: https://bit.ly/3niFlHx

Murchison House Station

Internet access - providing socioeconomic benefits 8-Oct-19

Summary after first season

Calum Carruth and Annie Brox

Please note that cost for the upgrade of the Internet access systems was mainly paid directly by MHS

Before

NBN SKYMUSTER

Source: https://www.whistleout.com.au/Broadband/nbn-sky-muster-satellite-plans

Category	Item	Item units	Cost per Unit	No of GB	Total
Internet Access	Daytime - Office hour & Day/Evening Quota 7am-1am	Average GB per day	-	1.3	1.31
Internet Access	Nightime - Quota "off-peak" Quota 1am-7am	Average GB per day	-	3.9	3.93
Internet Access	Daytime - Office hour & Day/Evening Quota 7am-1am	Average Cost per day	$ 0.61	1.3	0.80
Internet Access	Nightime - Quota "off-peak" Quota 1am-7am	Average Cost per day	$ 0.20	3.9	0.80

GB Per month	Price
40	24.5
120	24.5
40	24.5
120	24.5

Category	Item	Item units	No Of	Total
Internet Access	Daytime Usable availability to family	Average GB available Per Family member	4	0.33
Internet Access	Daytime usable availability to staff	Average GB available Per Staff member	3	None
Internet Access	Nightime usable availability to family	Average GB available Per Family member	4	0.98
Internet Access	Nightime usable availability to staff	Average GB available Per Staff member	3	None

Av. GB Available
1.31
None
3.93
None

Estimated average speed 10MB/s total monthly available daytime quota 40GB for $1.6 per day

After

NBN IINET FTN accessed using Point-to-Point Wifi to Kalbarri

Source: Origo Quarterly Reports and Data collected from MHS

Category	Item	Item units	Cost per Unit	No of GB	Total
Internet Access	Unlimited All day	Average GB per day*	-	21.7	21.7
Internet Access	Unlimited All day	Cost per day	$ 9.34	21.7	9.34

GB Per month	Price	Monthly Cost/CAPEX 5 years	GB Max Per day	GB Monthly Average*
Unlimited	35	250	346	663
Unlimited	35	250	346	663

Category	Item	Item units	Per Cent	No of	Total
Internet Access	Actual usage family	GB Per Family member	80%	4	4.35
Internet Access	Actual usage staff	GB Per Staff member	20%	3	1.45

Av. GB Per Day
17.39
4.35

** Based on usage statistics*

Average speed is 14 MB/s with average total monthly usage of 663 GB for $9.34 per day, unlimted data

Table 3: Comparison of Internet services before and after

4.8 Service Monitoring and Maintenance for MHS

Origo successfully established Service Monitoring and Maintenance for MHS. We are continuously monitoring and managing all WLAN network devices from our Operations in Perth. Results from this monitoring and support service will provide data for potential upgrades and improvements as well as for quarterly reporting.

Origo successfully established Origo.farm monitoring and maintenance services on the 25 May 2018.

	STATUS	NAME ↑	MODEL	CPU	SIGNAL
	ACTIVE	B1 - BM2T	Bullet M2 Titanium	0%	
	ACTIVE	B1 - NB5ACGen2	NanoBeam 5AC Gen2	6%	-44 dBm
	ACTIVE	B1 - NSM5	NanoStation M5	10%	
	ACTIVE	B1 - TSPoE	EdgeSwitch 5XP	3%	
	ACTIVE	B2 - NB5ACGen2	NanoBeam 5AC Gen2	5%	-45 dBm
	ACTIVE	B2 - PB5ACGen2	PowerBeam 5AC Gen2	8%	-69 dBm
	ACTIVE	B3 - PB5ACGen2	PowerBeam 5AC Gen2	6%	-67 dBm
	ACTIVE	B3 - PB5ACGen2	PowerBeam 5AC Gen2	6%	-55 dBm
	ACTIVE	B3-B5-PBE5AcGen2	PowerBeam 5AC Gen2	19%	-86 dBm
	ACTIVE	B4 - PB5ACGen2	PowerBeam 5AC Gen2	8%	-68 dBm
	ACTIVE	B5-B3-PBE5AcGen2	PowerBeam 5AC Gen2	5%	-86 dBm
	ACTIVE	House1 - ES5XPPoE	EdgeSwitch 5XP	4%	
	ACTIVE	House1 - NSLM5	NanoStation Loco M5	1%	-61 dBm
	ACTIVE	House3 - NSLM5	NanoStation Loco M5	7%	-72 dBm
	ACTIVE	Shed - BM2T	Bullet M2 Titanium	1%	
	ACTIVE	Shed - NSLM5	NanoStation Loco M5	1%	
	ACTIVE	Shed - NSM5	NanoStation M5	11%	-47 dBm
	ACTIVE	TSPoE - Shed	EdgeSwitch 5XP	4%	

Figure 23: Example screenshot from the management interface, the figure shows that the processing is minimal (CPU) with a large margin for further utilisation and that signal strength (Signal) is well within limits and margins required for adverse weather events.

At the time of this report the MHS farming system and priorities is not clear, it is however expected that planning will commence when this has been clarified and Origo is expecting to continue providing services to MHS.

4.9 Social interviews on how the social aspect of farm business and life has changed

Below is based on an interview of Calum Carruth on the 8th and 9th of November 2018. It has not been possible to update with further information at this point. However, MHS remain engaged with MLA and are able to provide updates into the future beyond this project

INTERVIEW

Function(s) of interviewee: Owners and Partners – Calum Carruth and Belinda Carruth

The following provides a summary of interviewees responses to the specific subject matter.

4.9.1 Status before and after

4.9.1.1 Internet Services

Before: Existing satellite-based internet connection prior to this project speeds were not of any use and the quota so small that it ran out within a few days.

Mobile voice services were extremely poor, this has improved lately with a new mobile services tower in the Kalbarri national park, but the data is still very slow and expensive.

After: MHS can now use streaming services Daily. Normal business tools such as Internet banking are being used. Internet applications such as Whatsapp and Skype can be used around the homestead, yards and workshop.

4.9.1.2 Weather stations

Before:The closest weather station is in Kalbarri. This station does not represent the local climate at the station very much as it is close to town and the coast.

After: With the installation of a range of weather station data collection devices at MHS “It will be interesting to see if we can find a relationship between grazing patterns and data from weather stations. Also, having local weather stations is important for OHS, use of helicopters and aeroplanes and animal welfare during muster.”

4.9.1.3 Mustering systems

Before:The process has been manual. This means that a set water trap must be visited very frequently where the success rate and efficiency is very variable. This involves a drive to the water point where the water point is set and observe e.g. 5 goats or 20 goats where there is no opportunity to plan ahead.

After: Mustering cameras and automatic gates have been installed however further work is required beyond this project to develop mustering capability supported by digital data including images and gate control.

4.9.1.4 Cost-benefit Water Monitoring and Control

Cost-benefit has been calculated, this includes vehicle fuel, maintenance and staff travelling time. It is providing a clear conclusion that there has been substantial savings for water management and no catastrophic events while using the system. The total annual savings in water management, including cost of system amortised over 5 years, was calculated to be $39,500 per annum. This is more than 50% of the total cost of water management at MHS per annum which is at an average of $75,000-80,000 per annum, see table 4 below showing the cost-benefit analysis based on data given by MHS.

Murchison House Station

Operational Efficiency Water Management by using Origo.farm Water Management technology

8-Oct-19

Summary after first season

Calum Carruth and Annie Brox

Before

Source: Data provided by MHS

Category	Item	Item units**	Cost per Unit	No of	Total
Water Management	Weekly Fuel	$ Per km	0.256	1050	$ 269
Water Management	Weekly Maintenance	$ Per km	0.25	1050	$ 263
Water Management	Weekly Staff cost	$ FTE Day	200	3	$ 600
Water Management	Weekly Incidentals*	$ Per day	300	3	$ 900
Water Management	TOTAL Summer	$ Per Week			$ 2,031
Water Management	TOTAL Summer	$ Per 6 months	$ 2,031	26	$ 52,800
Water Management	Fuel	$ Per km	0.256	700	$ 179
Water Management	Maintenance	$ Per km	0.25	700	$ 175
Water Management	Staff cost	$ FTE Day	200	2	$ 400
Water Management	Incidentals*	$ Per day	100	2	$ 200
Water Management	TOTAL Winter	$ Per Week			$ 954
Water Management	TOTAL Winter	$ Per 6 months	$ 954	26	$ 24,800
	AVERAGE TOTAL ANNUAL COST (rounded down)				**$ 77,600**

Trips	Km	Fuel per 1Km	Cost per Litre	Cost per Km
3	350	0.16	1.6	0.256

After

Source: Origo Quarterly Reports and Data collected from MHS

Category	Item	Item units**	Cost per Unit	No of	Total
Water Management	Weekly Fuel	$ Per km	0.256	350	$ 90
Water Management	Weekly Maintenance	$ Per km	0.25	350	$ 88
Water Management	Weekly Staff cost	$ FTE Day	200	1	$ 200
Water Management	Weekly Incidentals*	$ Per day	200	1	$ 200
Water Management	TOTAL Summer	$ Per Week			$ 577
Water Management	TOTAL Summer	$ Per 6 months	$ 577	26	$ 15,000
Water Management	Fuel	$ Per km	0.256	175	$ 45
Water Management	Maintenance	$ Per km	0.25	175	$ 44
Water Management	Staff cost	$ FTE Day	200	1	$ 200
Water Management	Incidentals*	$ Per day	100	1	$ 100
Water Management	TOTAL Winter	$ Per Week			$ 389
Water Management	TOTAL Winter	$ Per 6 months	$ 389	26	$ 10,100
	AVERAGE TOTAL ANNUAL COST (rounded down)				**$ 25,100**
	CAPEX Amortised over 5 years (ex R&D)		65,000		13,000
	TOTAL ANNUAL EFFICIENCY SAVINGS				**$ 39,500**

Trips	Km	Fuel per 1Km	Cost per Litre	Cost per Km
1	350	0.16	1.6	0.256

CAPEX	Yrs Amortised	Cost per Year
65,000	5	13,000

** Incidentals includes parts and tools*

*** Estimated average*

4.9.2 Socio-economic implications

The project has sought to collect both qualitative and quantitative information with regards to the socio-economic benefits of the project. With regards to water management it has been possible to collect quantitative information, however, with regards to Internet and weather stations, the information collected to date has been largely qualitative. Whilst overall business productivity benefits derived from improved connectivity remains to be fully quantified it can be stated that MHS now has Internet access on the same level as a small business in Perth.

With regards to social benefits, a key improvement has been staff being able to access the Internet to keep connected to family and friends which is important for health and well-being. . This is also important for business outcomes such as staff retention and training and education.

Calum Carruth stated that “It is possible to take control of the business, being able to go from react to plan for contingency and discover and plan before it is an emergency.”

4.9.2.1 Internet Services

Internet services is now the foundation for all operational efficiencies. It has made Internet usage a commodity for MHS. MHS is now operating as any small family business in for example Geraldton or Perth.

The Mobile booster system provided as part of the project ensures mobile phone coverage from most points on the station. MHS is fortunate as Telstra has prioritised another mobile tower in the Kalbarri national park which has improved the stations coverage as well.

MHS can now fully utilise online and cloud-based systems for accounting and management.

4.9.2.2 Weather stations

MHS is now able to see weather pattern from the coast to the easternmost part of MHS. This is important for daily planning of activities, (e.g. heat-load management). Weather data collected in-situ across MHS over a given time period is important to see localised trends in heat wave periods and how this is distributed throughout the stations at a scale not possible from publicly available weather information.

The Weather stations has already been shown to be very useful e.g. during mustering. “If it is 40C in Weerinougouda [furthest east on MHS] the likely mustering success would be good, even if the temp and the homestead is only 32. We can now also see trends.”

4.9.2.3 Mustering systems

These are divided into two use cases:

1. Water trap systems already established through MHS.
2. Mustering areas with fence wings, including smart fence wings developed by MHS.

Initial hypothesis with regards to the systems was discussed to be a combined camera and gate-closure systems that can be viewed and controlled on the Dashboard. However, this has been changed through development iterations to be separate and autonomous. This enables MHS to utilise the cameras in both use cases whereas the gate-closing mechanism is only relevant in use case 1.

4.9.2.4 Water Monitoring and Control

Quantitative

MHS has estimated that the savings already, during the implementation and testing period, in relationship to the benchmark established is in the order of $40,000 per annum including CAPEX amortised over 5 years, see table 4 above. This is based on (Refer table 4.):

- No blockages of water pipelines have happened this summer. Blockage repairs costs estimates to $2000-5000 in staff costs, fuel and repairs per incident.
- No tanks have emptied due to leaks this summer with direct costs with regards to recharging tanks in diesel fuel and staff costs. Costs per incident range from $1000-3000 per incident in staff costs and repairs.
- Direct saving in saved staff, fuel and maintenance costs due to less costs just to check water points and being able to target resources.

Qualitative

- Safety e.g. not having to chase around checking water after a mustering means less fatigue and better staff performance and safety.
- Ensuring animal welfare and supply quality. For example, (pers. Comm. Calum Carruth):
    - Received an SMS because one of the tanks was below 50% fill level. Flow data was checked and identified a spike. However, this was very late so could not find leak in the dark. The tank was turned off and very little water was lost. The leak was repaired in the morning. An estimated 20kL of water estimated to be saved.
    - Identified a leak on the Dashboard in outflow at Yatthoo Tank early April. This tank provided water to around 1000 mustered goats when away from the station in Geraldton.Immediately started the diesel pump remotely to supply water and directed staff that identified that one of the troughs was leaking.
    - Savings in switching off pumps remotely, can make sure that water is not wasted.

  In both these incidents avoidance of heat stress is an issue for the animals. Heat stress can lead to direct losses of animals with flow on commercial losses for MHS and impacts on owners and staff.

4.9.2.5 *Feedback - Change in work patterns*

Calum Carruth stated that MHS can already see a change in work patterns and opportunities for improvements with regard to water usage, leaks or pump failure for all tanks as well as in an outflow. Water management has become easier and less expensive. This change has freed up both time and resources allowing Callum and Belinda focus more closely how staff are working and identify areas for improvement.

Mustering Camera and remote gate control

The interview focussed on future targets for the muster of goats. However, the last mustering season (summer 2019/20) was dominated by exceedingly small herds of goats distributed over a large area. This could be attributed to little growth in the population or successful musters in previous years. The initial operational tests were successful, however, Origo has developed the hardware to provide the required functionality, but few customer requests, including MHS priorities, has meant that Origo has not been able to prioritise software development.

4.9.2.6 Questions for quarterly reporting and Answers as of this report

What are the 3 most important digital tools you have been using in your Farming operations before the project? These could be Apps, Desktop Software or Online Tools

- Weather forecasts - Long-term forecasts
- We have tried to use BOM data such as long-term forecasts, however, these are ridiculously inaccurate.
- We have been trying to use mobile phones more, but the coverage was not there. This has improved lately, but not much.
- We wanted to use satellite imagery but download speeds too slow and expensive, so we are going to look into that now.
- Until now, we have not been using digital tools in any systematic way.

Are there any digital tools you have tested and disregarded?

- Tried game cameras, but not efficient, had to drive out there to get footage.
- Briefly looked at drones. Drones are not practical because wind conditions are normally severe. Also, cannot see how drones can move cattle, goats or other livestock when helicopters are often struggling.

Please rank tools in priority to your farming operations?

- Currently not applicable.

If you are not using one or more of the above tools, please rank in importance to your farming operations, what type of tools would you like to use within 3 years?

- Currently not applicable.

Are you using digital tools for your day-to-day farm operations?

- Currently not applicable.

Ranking of farm data in priority

1. Water

The ability to monitor water assets in near to real time and monitor trends in water usage has resulted in early identification of leaks and or pump failure. Additionally, the implementation of digital monitoring and control has achieved a greater than 50% reduction in water monitoring, labour required and incident losses. Allowing an increased focus on other key management areas such as staff operations.

2. Weather

Noticed how different weather patterns are within the station, wind especially. Need to be revisited.

Update frequency, how up-to-date do you want the data to be to be useful in your operation?

Update frequency has been every 1 minute.

- Every 10 minutes would be enough?

Please prioritise computerised data analytics and alerts in importance?

- Avoiding tank empties as it stirs up sedimentation in the bottom of tanks, destroyed equipment and creates stock stress – animal welfare. A tank empty can cost a week at work.
- Identify and Find the section of pipeline leaks more easily.
- Alert if the flow rate change is changing – e.g. establish stock drinking patterns, alert when it changes.
- Simple alert when above and below a certain level.

Are you using integrated agriculture business systems?

- Currently not applicable.

Any other comments?

Looking at adapting smart fencing to wild dog problem if we can use cameras or sensors to monitor the situation.

4.10 Additional value adoption: New thoughts/ideas on how to value add the system

4.10.1 Irrigation for drought-proofing

Calum Carruth has stated that "We would like to change our farming system. We have efficiently been de-stocking for many years and would like to change over to a more controlled livestock farming system. Also, we are seeing that there would just be a matter of time before the dogs move into the area. Other areas with pastoral goats have made it impossible to farm rangeland goats. Also, the change in climate means that we can expect a change in weather patterns, and we have had an increasingly drier climate in the last five years.".

As MHS is located at the Murchison River catchment endpoint as it enters the Indian ocean, as there are substantial deposits the aquifer is large and stable as it is being fed by the whole catchment.

Again, stated by Calum Carruth: "We would like to develop and change our farming system to a more controlled livestock system where we can grow feed sustainably through the season. With our location and home paddocks, we have the land to develop this and we would like to do this with a system where we can control water usage very closely to ensure sustainable use of water resources."

"We are seeing this tie in closely with the Water management system provided by Origo.farm as we can use Weather stations and sensors to ensure a high level of efficiency in plant growth and water usage. The local conditions are very harsh, and it will be very important to find the ideal watering times combining plant and weather conditions and the danger of wind burn."

4.10.2 The following ideas have been discussed during Phase 1 and Phase 2.

- Drought-proofing for stable feed, to assist in a change of farming system – irrigation system integrated into the same system with automation connected to weather stations.
- Develop smart fencing systems with automated gates for mustering
- Develop smart fencing system to assist in wild dog eradication.
- Software development to automate water management and usage in addition to the remote control.
- Automation and alerts through user-guided models (establishing e.g. thresholds and change rates). These can be from simple equations, through statistical models through to Machine Learning Models (AI) for water management.
- Looking into establishing more weather stations to enable use in spatial modelling of weather data and vegetation to create localised pastoral status models and maps for use in rangeland livestock operations.
- Defining a project to develop local spatial models for grazing conditions based on local weather stations and vegetation mapping derived from satellite imagery.
- Tracking and Messaging device with GPS in the Meshing 900MHz network.
- Develop a model to estimate stock numbers based on water flow sensors to troughs. This can later be combined with RFID tag readers at troughs.

4.11 Information available for MLA Website and Media release

Provision of text and photos for MLA Website and media releases. High-resolution photos, as well as map information, is made available on the following link: https://bit.ly/3niFlHx

Please contact Origo for assistance with narrative beyond information given in this report.

5 Conclusions and recommendations

5.1 Station Ag IIoT Network

As a result of this project Origo and MHS has tested and implemented two different Ag IIoT networks:

1. Meshing 900MHz IIoT network with a Point-to-Point Wifi network as a backbone.
2. A Meshing 900MHz IIoT network only.

Both networks cover approximately the same area.

The implementation phases have shown that additional repeater stations are required in challenging areas. This is mainly due to the limited power output of the 900MHz meshing radio modules.

Origo has studied available 900MHz modules and recommends usage of higher power output modules. This has now been used in other producer customer cases with success.

5.2 Weather Stations

The conclusions with regards to the use of weather data are twofold:

1. Weather data will be used in daily operations to understand current and daily weather conditions to ensure OHS and animal welfare as well as for rainfall data for understanding and better utilisation of growing conditions in the bush and paddocks.
2. Use of localised weather data to understand grazing conditions. This will include researching calculated values and spatial analysis as well as presentations to be directly relevant to pastoral operations.

MHS is not currently using spatial data and relies on subjective analysis of weather station data and trends available on Origo Dashboards which has been sufficient for their farming system. The farming system is primarily based on rangeland goats which are not part of a controlled grazing system. Cattle can also be mustered to paddocks during calving. Additionally, weather data is used for to support decisions in relation to production of hay on a small area close to the homestead.

Recommendations:

- It is important to increase skills in utilising and doing simple analysis based on data.

5.3 Water monitoring and control Systems

Use cases such as Water Management for MHS provide a clear case with regard to how a farming system can utilise data to enhance business productivity and profitability. Currently, data from stations is interpreted and presented in a web-based Dashboard system. This enables MHS to make decisions based on this information with regard to control systems or staff actions.

However, automation of water management based on data from water monitoring systems is the next logical step as this would provide information and create actions based on rules implemented in software. This will create efficiencies as user-defined rules could be implemented and changed on-the-fly. However, this is not a simple automation with "if-then-else" but requires user administrated thresholds and automation-rules to enable changes in automation as operational changes occur during a season or by a change in the farming system.

At the current time it is not clear what farming systems MHS will select for the future.

Origo and MHS would recommend:

- Explore the development of a project to develop models for automation and alerts through user-guided models (establishing e.g. thresholds and change rates). These can be from simple equations, through statistical models through to Machine Learning Models (AI) for water management.
- Software development to automate water management and usage in addition to the remote control.

5.4 Integration of 3rd Party Data

Use of Open source systems shows its strength as it was very simple for Origo to integrate data and implement a user interface for vegetation index and pasture status from Cibolabs. The cost of this development has been covered by Origo and Cibolabs.

However, the conclusion is that spatial data with regards to pasture quality was not relevant for the MHS farming system.

5.5 Mustering Systems - IIoT Camera and Remote Gate Control.

It is too early to provide any conclusions from the use of mustering systems.

The technical testing of the camera systems showed that further development to simplify use was required. This was implemented in new hardware; however, software development has not been prioritised at the current time.

The Gate Control mechanism was based on a product already developed by Origo, and only the gate mechanism itself was developed in the projects. The Origo Control Station electronics is one of our standard products used in a multitude of projects. However, there has been no further customer requests for remote gate control by the producers, so Origo has not prioritised this development.

5.6 Internet usage and performance

It is our clear conclusion that MHS now has access to Internet services on the same level as businesses and residential homes in Australian cities.

- Average Internet data usage is 461 GB per month.
- Service stability enables the use of Internet business applications
- Low latency enables the use of interactive applications and services such as Skype, Wifi Calling and VoIP.
- However, Internet speed at the Internet services provider interface in Kalbarri prohibits use by more than 4-5 concurrent users with moderate demands on bandwidth. It is therefore recommended that MHS implements some guidelines with regards to Internet usage to ensure no disruption to business use. E.g. Heavy use of video streaming services during business hours will reduce the quality of e.g. Wifi calling.
- Internet Services operators overseas are providing Internet services with guaranteed bandwidths. However, there are no affordable and comparable services made available through the national Internet service portfolio available to MHS currently.
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Before and After Analysis, see table 3 above.

MHS and Origo would recommend:

- MLA to work with federal authorities and policymakers to ensure the provision of business grade service, or at least Internet service on the level as used in this project, to all producers in the meat and livestock industry.
- MLA to establish an Internet services benchmark for the meat and livestock industry by which federal and telco industry initiatives, such as the NBN, should be benchmarked against.